it is useful; secondly, we have established the great principle of "correlation of growth," which is a brief way of stating that in organisms there is such an intricate binding together of the mechanism that when one part varies other parts vary concomitantly—so that a useful variation of the beak or eyelid of a bird (for example) may *necessitate* a concomitant and perfectly useless variation in the toe-nails or the tail-feathers, thirdly, useless structures undoubtedly exist owing to the potency of heredity, which is of such strength that long after a structure has ceased to be a matter of selection it is transmitted from generation to generation, though dwindled in size and more or less imperfect in structure.

I think there will be no difficulty by reference to one or other of the three considerations above stated in disposing of cases of so-called "uselessness," or "prophetic" functionless organs "on the way to use," which the Duke of Argyll may find to be stumbling-blocks in the way of his faith in Darwin, if he will submit them one by one for pulverization, though I am afraid the process will not interest your readers.

September 21. E. RAY LANKESTER.

A Shadow and Halo.

A FEW evenings ago, whilst walking down a sloping pasture, with the moon shining brightly at an altitude of about 20° behind me, and with no visible dew nor fog, yet with heavy dew on the grass, I noticed that the shadow of my head and shoulders was very sharply defined, but that it was surrounded by a halo of light, and that this halo or nimbus increased in brightness as my shadow was lengthened out because of the increasing slope; and not only was the brightness increased, but it extended now to my hips. That this was due to the greater depth of moist air through which the moon's light passed, by reason of the increase of the slope, I think was proved by the fact that in the neighbourhood of a high hedge, which would to some extent alter the conditions, this halo nearly wholly disappeared. At one time I thought that my eyes were deceiving me concerning this appearance, the contrast of the dark shadow with the surrounding brightly illuminated grass giving rise to the appearance above mentioned, but, by holding up my hand so as to cut off the view of the shadow, I still saw the brighter light which surrounded it, and this brightness still increased or decreased in intensity as the slope on which I took up my position was greater or less. There was no casting of a shadow on a fog-bank, as there was no fog at all, but rather the air was particularly clear. I noticed this phenomenon three nights in succession. I shall be glad to know if any other amongst your readers has noticed this occurrence, and will explain it. E. W. P.

Tamworth, September 29.

Sonorous Sands.

REFERRING to Mr. Carus-Wilson's letter recording the supposed discovery of musical sand in Dorsetshire, I may mention that about two years ago the late Admiral E. J. Bedford sent me three boxes of musical sand, one of them being labelled, "Musical sand; Studland Bay, Dorset, 1885; sonorous when collected." I am not aware whether Admiral Bedford himself discovered the sonorous properties of this sand, but it is clear that he was well acquainted with both the sand and its character in 1885. A. R. HUNT.

Torquay, September 27.

THE REPORT OF THE KRAKATÃO[1] COMMITTEE OF THE ROYAL SOCIETY.

I.

AFTER an interval which has been prolonged partly by the unexpected continuance of the subsequent atmospheric phenomena, and partly through other circumstances incidental to publishing, the Report on the great eruption of the volcanic island of Krakatão in August 1883 is now before the world.

Every Committee is bound to issue a Report of some kind, but it rarely falls to the lot of a Committee to deal with anything at once so stupendous in its character and far-reaching in its consequences as the eruption which not only figuratively, but literally, vibrated through the world on August 27, 1883.

We, in these islands, may boast of our Essex earthquakes, and of the frequent little tremors to which a certain district in Perthshire is subject; but few of us, or our immediate neighbours, can, from our local experience, form the faintest conception of the terrific subterranean powers which ordinarily manifested themselves in the volcanic region of which Krakatão may be fitly termed the *focus*.

The first accounts which reached us by telegram, inaccurate though they were bound to be as regarded details, were scarcely exaggerations in point of magnitude; and, indeed, the cataclysm in this case rose superior to all artificial modes of transmission, by announcing the very date and hour, if not minute, of its culminating explosion through a series of air-waves, which recorded themselves no less than four times on every automatically recording barometer throughout the world.

Three other distinct and abnormal phenomena were: (1) the immense distance to which the sound-waves were propagated (altogether transcending anything hitherto on record; (2) the immense local height, destructive power, and subsequent wide diffusion of the accompanying sea-waves, which in this case were *not*, as is usually the case, due to earthquake action; (3) the simultaneous occurrence in the Javan and Indian area, and subsequently rapid extension, first round the equatorial zone, and, finally, to the whole world, of a most remarkable group of optical phenomena, including coloured suns, lurid and prolonged glows at twilight, large coronæ round the sun and moon, and a peculiar cirriform haze which was evidently connected in some way with these and the eruption.

It was plain, in the face of these preliminary facts, that the collection and discussion of such a grand series of exceptional phenomena gratuitously evolved out of Nature's own laboratory, could not fail to be of service to science, and that while the more local features and practical results of the episode might be left to the Dutch Government, to whom the district belonged, its attendant and subsequent phenomena deserved permanent record in the pages of scientific history.

On this basis, a Committee of the Royal Society was appointed on January 17, 1884, in the following terms:—

"That a Committee, to consist of Sir F. Evans, Prof. Judd, Mr. Norman Lockyer, Mr. R. H. Scott, General Strachey, and Mr. G. J. Symons, with power to add to their number, be appointed to collect the various accounts of the volcanic eruption at Krakatão and attendant phenomena in such form as shall best provide for their preservation and promote their usefulness."

The subsequent expansion of the Committee by co-operation of additional members, and the substitution of one—Captain Wharton—in consequence of the death of Sir Frederick Evans, is detailed in the preface.

The main object of the Committee was thus to collect facts and reduce them into a systematic and useful form. While this has been its primary object, it has been thought advisable to enlarge upon the original basis of the Report, and, while giving a *résumé* of all the leading opinions, especially those relating to the debated question of the relation of the optical phenomena to the eruption, to enter at some length into a discussion of the facts thus systematized. Though it is hardly to be expected that everybody will agree with the deductions arrived at by each author, and though it has been impossible to avoid omissions in a work embracing, in its latter sections, observations extending over three years, and a literature of its own, the main facts have not only been recorded, but, as the Chairman, Mr. G. J. Symons, says, can be readily verified.

Although, therefore, as time progresses, and human knowledge changes and enlarges, some of the conclusions drawn by the authors of the Report may be modified or reversed, the value and permanence of the facts and opinions quoted, will be secured by the unusual care which Mr. Symons has taken to verify all the references and quotations.

The work is divided into five parts:—

I. On the volcanic phenomena of the eruption, including the nature and distribution of the ejecta, by Prof. Judd, F.R.S.

II. On the air-waves and sounds caused by the eruption, prepared under the direction of Lieut.-General R. Strachey, F.R.S.

III. On the seismic sea-waves caused by the eruption, by Captain W. J. L. Wharton, R.N., F.R.S.

IV. On the unusual optical phenomena in the atmosphere which began in 1883 and continued in part up to 1886 inclusive, and which included coloured suns, twilight effects, coronal appearances round sun and moon, sky haze, &c., by the Hon. F. A. Rollo Russell and Mr. E. Douglas Archibald. And

V. A short discussion of the magnetical and electrical phenomena, by Mr. G. M. Whipple.

Prof. Judd commences by pointing out how peculiarly favourable for the gigantic outburst was the position occupied by Krakatão. The marked linear arrangement of the volcanoes of Java and Sumatra points to the existence of a corresponding great fissure in the earth's crust; while across the Straits of Sunda lies another line of weakness, along which five volcanoes have been thrown up at different epochs. Krakatão lies precisely at the intersection of these lines. It is therefore a position where volcanic action, once having commenced, might be expected to display itself on its grandest and most intense scale.

The history of Krakatão, as traced by Prof. Judd, shows that, both in dimensions and activity, it may be considered to have been one of the largest and most destructive volcanic craters in the world. At one time, "its circumference, at what is now the sea-level, could not have been much less than twenty-five miles, and its height above the same datum plane was perhaps not less than 10,000 to 12,000 feet."

Then, at some unknown period, a terrible outburst seems to have occurred, far transcending the present one, which completely eviscerated the volcano, and reduced it to the condition of a basal wreck of three islands, one of which contained Rakata, a basaltic lava cone from which the island derived its name, and two smaller parasitical cones; while the other two represented the relics of the original crater, formed of the same material as the latter, viz. enstatite dacite. The relatively inconspicuous character of Rakata, and the adjacent cones and islets, as well as the absence of any serious volcanic action since 1680, seem to have warded off any suspicions which might have been entertained by the inhabitants on the adjacent coasts regarding either the former grandeur of the volcano or the possible renewal of its activity, certainly on such a scale as was witnessed on August 27, 1883.

Nature, however, rarely displays its grandest effects without giving premonitory warnings, and, in volcanic and seismic phenomena more particularly, by exhibiting the culminating outburst as the cumulative result of an aggregation of small and continuously operating hypogenic causes.

For some years prior to 1883, earthquakes had been of frequent occurrence in the vicinity, one of which destroyed the lighthouse on Java's First Point, and was felt even in North Australia, while on May 20 and 21 an eruption proceeded from Perboewatan, the most northern of the three craters which occupied the place of the original prehistoric volcano, and the same that was in eruption in 1680. This eruption, though only of a relatively mild (Strombolian) type, compared with its successor, was yet sufficiently striking to be accountable for some of the sporadic sky effects which, as we shall see, were noticed in its vicinity during and for some little time after its occurrence. For example, the captain of the German ship *Elizabeth*, when passing through the Straits on May 20, observed the height of the smoke column as it issued from the volcano to be over 30,000 feet, and found dust fall on his ship when it was more than 300 miles distant; while, according to Verbeek, the writer of the Dutch Report, the sounds were heard not merely at Batavia and Buitenzorg, 100 miles off, but even at Singapore, which is 518 miles away.

After this relatively minor, though absolutely violent eruption, a period of intermittent and subordinate activity prevailed, during which two other dormant cones reopened, the decrease in violence being thus probably made up for by the larger area in eruption. Finally, after a period of growing intensity—a fact which was attested by observations at Batavia and on board ships passing through the Straits—the entire volcano appears, on August 26, to have passed from the moderate (Strombolian) stage to the paroxysmal (Vesuvian) stage.

It would be unnecessary to recapitulate the accounts given of this terrific outburst, which lasted from 2 p.m. on Sunday, August 26, to the evening of August 27, and reached its culmination at about 10 o'clock on the latter day. The originals read like romances from the "Arabian Nights," though to attempt to adequately describe such a chaos would need the pen of a Dante coupled with the pencil of a Doré. The salient features were (1) the unusual height to which the smoke column was observed to ascend, viz. seventeen miles, by Captain Thomson, of the *Medea*—the nearest approach to which on any former occasion seems to have been thirteen miles at the eruption of Graham's Island (Julia) in 1831; (2) the extraordinary violence of the detonations; and (3) the accompanying atmospheric and electric phenomena. With respect to this latter point, the volcano was, in fact, a frictional hydro-electric generator of electricity on the largest possible scale.

One of the most important deductions arrived at by Prof. Judd from a study of this and other eruptions is the precise part played by water in aiding eruption.

It appears to be often thought that both slow percolation and the rapid introduction of water into reservoirs of lava are the direct causes of eruption; but Prof. Judd shows that, while the percolation of water is one of the contributory causes, it is not *the* primary cause, which he attributes, when discussing the nature of the materials ejected, to "the disengagement [by heat] of volatile substances actually contained in those materials."

According to this, which may be termed the "cartridge" doctrine of eruption (the lava representing both the powder and shot), the action of inrushes of sea-water, such as occurred in the present case, by chilling the surface of the lava, and augmenting the tension of the imprisoned gases, caused "a check and then a rally," analogous to what occurs in a geyser when sods are thrown into it. Prof. Judd attributes the excessively violent nature of the last stages of the great eruption of Krakatão to this "check and rally action," caused by the dissolution after evisceration of the crateral framework of the volcano, and the consequent admission of the sea in large quantities, a circumstance to which its position rendered it peculiarly accessible.

Prof. Judd considers the "*excessively violent though short paroxysms* with which it terminated" to be the special feature by which the eruption of Krakatão differed from others of similar rank. These, while characterized by a larger quantity of materials ejected, present no parallel to the final "exhaustive explosions of abnormal violence," together with the vast sea and air waves, and the subsequent optical phenomena, which accompanied that of Krakatão.

Prof. Judd next deals with the nature of the materials ejected, and draws attention to the different *physical* characters presented by the lavas ejected from Krakatão at different epochs, the final compact lavas of 1883 being porphyritic pitchstone, and obsidian, containing about 70 per cent. of silica, and so nearly identical *chemically* with those of some of the earlier outpourings as to suggest refusion.

The heavier lava dust which fell in Java and was examined by numerous geologists, including Prof. Judd himself, exhibits a peculiarity which he considers to be without precedent, in that it contains almost every variety of feldspar crystals. The base in which these crystals was found to be embedded presents great differences in its fusibility, the pitchstone melting with great difficulty, and the obsidian with ease. This latter point, in combination with other circumstances, leads Prof. Judd to one of the most important of his conclusions, viz. as to how eruptions come to differ not merely in magnitude but in quality: for example, how a volcano such as Krakatão at one time emits massive and viscous lava-streams as it did in former times; at another, pours forth a more liquid lava; and again, as on this occasion, bursts out with explosive violence into an eruption in which most of the lava is converted into pumice. He considers that the older lavas have been *chemically* acted on by water which has slowly percolated through the crust in the vicinity, and that the new compounds thus produced are not only more readily fusible, but more easily convertible into pumice. Volcanic action is thus concluded to be brought about not directly by the physical action of externally derived water, but by changes in the physical properties of rocks chemically altered through the medium of such water.

In connection with the optical effects which were witnessed subsequent to the eruption, and which are found to be connected chiefly with the finer solid ejecta, Prof. Judd finds evidence, both from a study of the Krakatão pumice as well as the finer dust which fell at great distances, that by the unusual violence of the explosions during the major outburst a large quantity of the very finest threads and dust of volcanic glass was thrown out into the higher atmospheric regions, where it might remain suspended for very long periods. He also points out that the absence of any sign of materials characteristic of Krakatão in the rainfall of distant places is no evidence against their wide diffusion, since the most characteristic substance in the Krakatão dusts was rhombic pyroxene, and this by reason of "its high specific gravity and its slight friability would be among the first to fall."

Prof. Judd brings his section to a close by a general review of the circumstances which have led him to adopt the view already enunciated regarding the cause of volcanic action, viz. that the liquidity of a lava and the violence of an eruption depend on the extent to which the lava has, as it were, been hydrated under the influence of slow aqueous percolation. Lavas of precisely the same composition, and at the same *temperature* may vary greatly in their eruptive action simply by the changes thus effected in their fusion-points. This refined form of the volcanic theory, which is put forward by Prof. Judd, appears to show that the Vesuvian stage of eruption is a paroxysmal form of earth sickness, due to lava gases indirectly generated by water action, while the quiet outpourings both from cones and fissures which have taken place so widely both in the past and present ages, represent the more normal welling up of lava which has been less altered by water action. For this reasonable deduction and the clearer insight afforded into the *modus operandi* of volcanic and seismic phenomena, we are, without doubt, indebted to Krakatão.

(*To be continued.*)

THE BRITISH ASSOCIATION.

SECTION H.[1]

ANTHROPOLOGY.

OPENING ADDRESS BY LIEUTENANT-GENERAL PITT-RIVERS, D.C.L., F.R.S., F.G.S., F.S.A., PRESIDENT OF THE SECTION.

II.

THE accompanying map of Great Britain shows the monuments that I have been the means of obtaining by the consent of their owners.

The Pictish Tower at Mousa in the Shetlands, which is well known to be the best preserved monument of this class in the country, has been included by the owner, Mr. Bruce, and some necessary repairs have been done to it by the Government. In the Orkneys the owners of the scheduled monuments declined to make use of the Act, but they are well looked after. The same applies to the Bass of Inverurie, the Vitrified Fort on the hill of Noath, the Pillar Stones at Newton, in the Garioch, and the British settlement at Harefaulds, in Lauderdale, which latter, however, is in such ruinous condition that the remains of it are scarcely worth preserving. The Suenos Stone near Forres; the Cairns at Clava, on the banks of the Nairn; the Cat-stane at Kirkliston; the Burgh of Clickanim, have also been withheld by their owners, but most of them are very well taken care of. The Cairns at Minnigaff were nearly destroyed before they were scheduled, and are not worth preserving. The inscribed stone in St. Vigean's churchyard is preserved in the porch of the church, but it is not included. On the other hand, Edin's Hall, the largest and most southern of the remains of the Pictish Towers in Berwickshire, has been included by Mr. J. S. Fraser-Tytler; the Black and White Catherthuns have been added by Miss Carnegy Arbuthnot; both these are large camps having ramparts of stones and earthworks round them, and they are described in General Roy's work. The Pictish Towers at Glenelg have been included by Mr. James Bruce Bailey; they are in a very bad state of repair, and have been propped up by the Government. The inscribed stones at Laggangairn, New Luce, have been included by Lord Stair; they are at a great distance from any road or habitation, and the protection afforded them, beyond the powers contained in the Act, must be regarded as nominal. The Peter's stone, on the road from Wigton to Whithorn, has not been added; it is an important stone, and is in a dangerous position; it has already suffered damage, and it is to be hoped it will be included hereafter. The chapel on the Isle of Whithorn, supposed to be that built by St. Ninian, has been included by Mr. R. Johnstone Stewart; this was not in the schedule. The Pillars of Kirkmadrine have been included by Mrs. Ommaney McTaggart; they are the earliest Christian monuments in the country. I suggested that Government should contribute towards building a small chapel to contain them, which has been done. The Cross at Ruthwell, with its remarkable runes, which were gradually being destroyed and covered with lichen, so that its inscription could not be read, has also been added. I suggested that the Government could contribute towards building an annex to the neighbouring church to contain it, which has been done. This was not in the schedule. The cup-marked rock of Drumtrodden, Wigtonshire, has been added by Sir Herbert Maxwell, and Government has granted a certain sum towards building a shed over it to preserve it. It was not in the schedule, but is a good example of its class. Barsalloch Fort, Wigtonshire, the Moat Hill of Druchtag, the Drumtrodden standing stones, Wigtonshire, have also been added by Sir Herbert Maxwell. St. Ninian's Cave, with its early Christian crosses, has been included by Mr. Johnstone Stewart. In the Island of Lewis the remarkable standing stones in the form of a cross at Callernish, and the Broch at Carloway, have been added by Lady Matheson. This latter is, next to Mousa, the best Pictish tower in the country. In Cumberland, the Stone Circle on Castle Rigg has been put under the Act by Miss Edmondson. In Westmoreland, Arthur's Round Table, an earthen circle with a ditch in the interior, and Mayborough, a large circle with an embankment of stones and the remains of a stone circle within, has been included by Lord Brougham. In Derbyshire, Arborlow, a large circle similar to Arthur's Round Table, with the remains of a stone circle, the stones of which are prostrate, and a large tumulus near it, has been added by

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[1] Continued from p. 518.